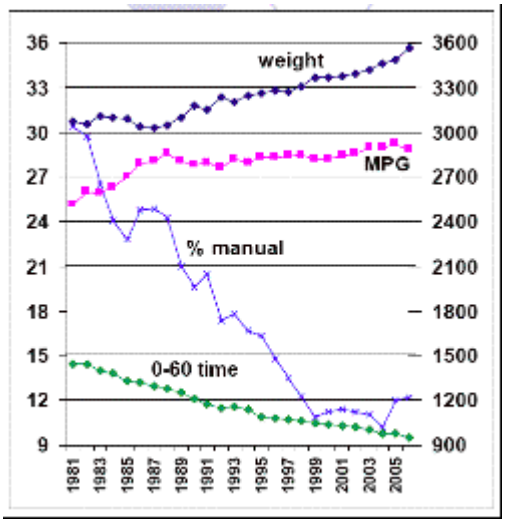
The Future of Transportation

Can we drive less, in more efficient vehicles, and use fuels with lower greenhouse gas emissions? Can we make this change quickly enough to reduce total greenhouse gases from transportation by 60 - 80 percent by 2050? These were the questions discussed at the 11th Biennial Conference on Transportation and Energy Policy at the Asilomar Conference Center in Monterey, California. The Institute of Transportation Studies at the University of California, Davis, organized the conference. Dr. Dan Sperling, who is also a recently appointed board member of the California Air Resources Board, heads the institute. This article has been developed from the presentations at the conference and the opinions of conference attendees from the international, academic, governmental, non-governmental and business communities. (See Asilomar 2007 at http://www.its.ucdavis.edu/events/outreachevents/asilomar2007/presentations%20list.php for a complete list of presenters and their presentations.)

Overview

Transportation accounts for 25 percent of worldwide greenhouse gas emissions, and demand for all modes of transportation is expected to increase. Over the next 20 years air travel is expected to double and airfreight is expected to triple. As manufacturing moves overseas seeking cheaper labor, many of the goods travel back by air, using significantly more fuel and producing more greenhouse gases than if manufacturing remained in the United States.

Global wealth has increased three-and-a-half times over the last 35 years and more than 5 billion people want to get out of poverty. As they do, they seek a higher standard of living, which means higher energy consumption in general and greater use of motorized personal transportation.

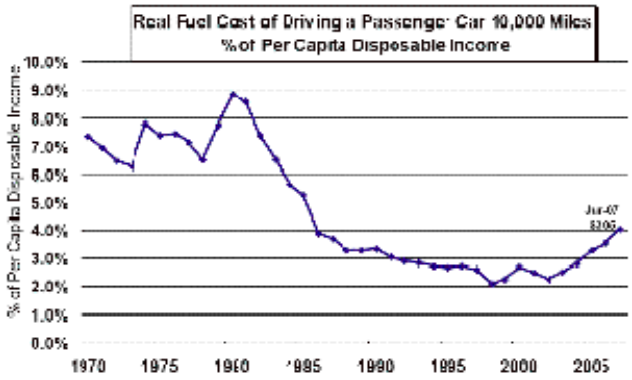


Over the last 20 years, passenger vehicles have become heavier and have faster acceleration but have no improvement in fuel efficiency.

In 2006, Americans drove 3 trillion miles. The passenger fleet averages 21 miles per gallon. "Merely" doubling fuel efficiency is not enough to cause an actual reduction in fuel consumed, as current estimates claim travel will increase to 7 trillion miles by 2035. Studies of U.S. consumers show that **fuel economy just nudges out exterior paint color** among factors that influence their decisions about which new car to purchase! As the chart to the right shows, weight and acceleration have increased significantly and drivers have "shifted" to automatic transmissions while new vehicle efficiency has flattened. In fact, the engine's fuel efficiency has increased by 1.3 percent annually since 1981. That's what it took to keep the higher performance, heavier vehicles from dropping in fuel efficiency. If, instead, acceleration and weight had been held constant, the fleet average would be at 38 MPG today.

Price Signals Are Not Enough

Fuel is still relatively inexpensive. The inflation-adjusted average fuel cost per mile increased from 14 cents in 1970 to a peak of 20 cents in 1981. It dropped to a low of 6 cents in 1998 and only recently reached 13 cents, when gasoline surpassed $3 per gallon. That might make one think fuel costs are about to become significant - but, as the chart at the right shows, comparing fuels costs as a percentage of disposable income shows gasoline would need to approach $6 per gallon to match the peak of 1980.



The creation of a price on carbon or a cap-and-trade scheme for transportation fuel would not change the costs very much. Carbon futures in Europe closed at US$31 per metric ton on October 12. A gallon of gasoline has 8.8 kilograms of CO2.[1] If European carbon fees were added to a gallon of gasoline, it would only increase the cost by 27 cents.

While the fuel price impact on passenger vehicles is very small, the impact on trucks is very different. A $30,000 passenger vehicle can be expected to use $20,000 of fuel during its lifetime. A $100,000 truck can be expected to use $400,000 of fuel. For trucking, fuel now costs as much as the driver.

If we are to reduce greenhouse gas emissions from transportation, it will take more than just higher prices. It will also require changes to current public policies.

New Thinking - New Solutions

It will require new thinking and new solutions to reduce greenhouse gases from transportation by 60 - 80 percent by 2050. It will take a combination of three strategies working together:

- Reducing vehicle miles traveled (VMT)
- Improving vehicle fuel economy
- Reducing the greenhouse gas content in fuel

Discussions at Asilomar gave examples of public policies that are working or have great promise. Their success all depend on politicians being able to resist the NIMTO (Not-In-My-Term-of-Office) attitude and show leadership.

Reducing Miles Traveled

Two examples stand out among policies that have reduced vehicle miles traveled. The City of London reduced traffic through a congestion charge combined with improvements in public transit. The City of Portland reduced vehicle miles traveled through growth boundaries and improved mass transit.

City of London

In February 2003, the City of London began charging £8 per day (US$16) for vehicles traveling in the inner city between 7:00 am and 6:00 pm on weekdays. There are no barriers or tollbooths. The charge is

[1] "Emission Facts: Average Carbon Dioxide Emissions Resulting from Gasoline and Diesel Fuel." Office of Transportation and Air Quality, United States Environmental Protection Agency. Doc. No. EPA420-F-05-001. February 2005. Available online at <http://www.epa.gov/otaq/climate/420f05001.htm>.

enforced through cameras and supporting electronic systems. The fee is heavily discounted for people who live within the city or have special needs. The results to date[2]:

- 16 percent reduction in greenhouse gas emissions from transportation within the inner city
- 20 percent reduction in traffic
- 30 percent reduction in congestion
- Reduction in traffic accidents
- Neutral effect on businesses
- Increased reliability and usage of buses
- Little change in the number of trips - just a shift in mode

Thanks to an integrated transportation system (road, bus, taxi, rail and underground), funds collected from the congestion charge are spent wherever they can achieve the greatest benefit. In effect, the people driving are paying for the system improvements that benefit those who take public transit or walk.

City of Portland

While per-capita VMT is increasing nationally at an average of 2.3 percent each year, in the Portland area it is declining thanks to reliable transit service, smart land-use planning and outreach programs. In the county of Multnomah, greenhouse gas emissions from transportation have declined by 16 percent between 1990 and 2004.[3] Regional growth boundaries combined with integrated transit planning have created higher density communities. This in turn has created high property values and profits for developers within the growth boundary.

While there is proof that cities can make a difference, federal policies have yet to focus on reducing VMT. Even though there is some evidence that VMT per capita is starting to stabilize in the U.S., we don't know for sure because half of U.S. states have stopped reporting VMT. They are concerned they will lose federal transportation funding, which is based on increased travel! Some transportation planners believe VMT in 2035 could be trimmed to 5 trillion vehicle miles (compared to the projected 7 trillion) and could, in fact, be held at 3 trillion if policies were changed to reward better urban design and transit over new freeway construction.

Improving Vehicle Fuel Economy

A complex combination of consumer purchase decisions, auto companies' estimates and government prerogative influences the setting of fuel economy standards. It is technically possible to make more efficient vehicles. The fundamental question is whether consumer buying criteria will change to prioritize fuel economy.

Role of Government

Government requirements for fuel economy vary widely. Europe and Japan have programs to reduce fuel consumption:

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[2] Evers, Mark. "Action Today to Protect Tomorrow: London's efforts to curb traffic growth." Transport for London. PowerPoint presentation. 22 Aug 2007. Available online at <http://www.its.ucdavis.edu/events/outreachevents/asilomar2007/presentations/Day%201%20Session%203/mark%20evers.pdf>.

[3] Burkholder, Rex. "CO2 Reduction Through Better Urban Design: Portland's Story." Metro. PowerPoint presentation. 22 Aug 2007. Available online at <http://www.its.ucdavis.edu/events/outreachevents/asilomar2007/presentations/Day%201%20Session%203/Rex%20CCAP%20Presentation.pdf>.

Region	Timeframe	Change	Improvement Rate
Europe	1995-2008	185 -> 140 gCO2/km	2.2 percent/year
Europe (proposed)	2008-2012	140 -> 130 gCO2/km	1.9 percent/year
Japan	2005-2016	13.6 -> 16.8 km/l	1.9 percent/year

The proposed European standard of 130 gCO2/km (grams CO2 equivalent per kilometer) is equivalent to 48 mpg diesel fuel efficiency (many European cars run on diesel) and 42 mpg gasoline fuel efficiency. The Japanese requirement of 16.8 km/l is equivalent to 40 mpg. A fuel efficiency provision in the current U.S. Senate energy bill requires the U.S. fleet to reach an average of 35 mpg by 2020 (this would require an average improvement of 4 percent/year). The California Clean Cars Bill (Pavley, AB 1493) would result in a 30 percent reduction in greenhouse gases from new vehicles by 2017 - assuming the U.S. EPA grants a waiver to allow implementation[4] to proceed. Other states - totaling 40 percent of the U.S. markets - have also adopted the Pavley regulations.

Should government provide the economic incentives to purchase more efficient vehicles? Consumer studies have shown that buyers tend only to consider the purchase price of the vehicle and not the cost to operate the vehicle over its lifetime. In a recent study, only one person in 15 had any idea what they spent in fuel per year. A proposal in California (see Clean Car Discount[5]) would provide a rebate of up to $2,500 for the most fuel-efficient vehicles and a surcharge for the least efficient. In principle, this would solve the fundamental disconnect in consumer buying behavior and would make the more efficient vehicles less expensive to buy.

Auto Companies & Technology

Significant opportunities exist to improve the fuel economy of vehicles. These include:

- Improved gasoline spark-ignition engines
- Turbocharged gasoline spark-ignition engines
- Hybrids
- Diesel engines
- More efficient transmissions
- Reduced vehicle weight, drag and tire rolling resistance
- Electric vehicles and plug-in hybrids
- Hydrogen-powered vehicles

John Heywood, Director of the Sloan Automotive Laboratory at MIT, gave the following assessment for 2035, based on an extensive computer model of automobile technology and auto industry economics (note this model includes turnover of the fleet and not just the fuel economy of new cars sold in 2035):

- A plausible combination of reduced vehicle weight and more efficient engines can halve fuel consumption by 2035. The cost of an average car will increase between 13 percent and 20

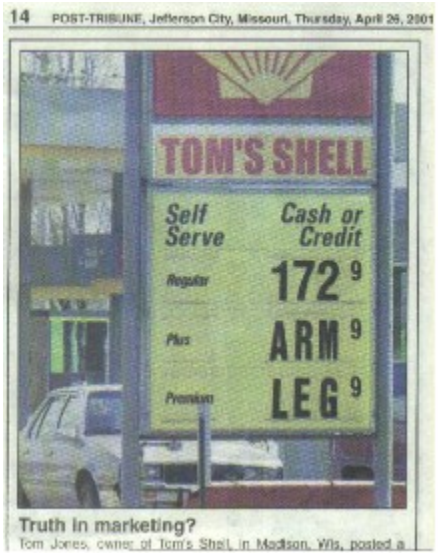
[4] "Supreme Court Ruling Removes Obstacle to California Clean Cars Law; Justices Say Heat-Trapping Carbon Dioxide is Pollution." NRDC. Press release. 2 Apr 2007. Available online at <http://www.nrdc.org/media/2007/070402b.asp>.
[5] Union of Concerned Scientists. "AB 493: Clean Car Discount for California Families." Available online at <http://www.e2.org/ext/doc/AB%20493%20Ruskin%20factsheet.pdf>.

percent, depending on vehicle mix, especially the market share of hybrids. The owner will recover this extra investment in 3-6 years due to reduced fuel costs.[6]

Auto companies are pursuing both hybrid engines and plug-in hybrids. Those technologies along with the opportunities outlined above will provide most of the improvement in the coming years (see Ford[7] and Honda[8] presentations). In the long term, the auto companies continue to pursue hydrogen-fueled vehicles. For example, there are now over 100 demonstration hydrogen cars being tested in California (see http://www.fuelcellpartnership.org/fuel-vehl_cars.html). Producing hydrogen from renewable energy sources and distributing and storing hydrogen presents a significant challenge - with strong proponents and equally strong doubters.

Consumer behavior

Consumer behavior is the biggest dilemma in fuel economy. So far, consumers have not had to do much to address the air quality or safety problems associated with automobiles. The government established performance standards and automobile companies complied, resulting in cleaner and safer vehicles. Why should fuel economy be any different? (The exception to this was air bags. Consumer pressure was needed to finally make them required.)



If there is a national security and environmental imperative, then government should establish standards. The photo here shows what was in April 2001 a shocking price for gasoline - $1.72/gallon. In fact, it isn't the price but the suppliers that cause the greatest risks. National oil companies (i.e. foreign government controlled), which control almost 80 percent of all the oil reserves in the world, make decisions on a political basis, not just on the basis of economic interests.[9]

In-depth studies of U.S. car buyers have found no evidence of economically rational decision-making about fuel economy (see Kurani[10] or Greene[11]). Out of 125 vehicle purchases, only in nine of them did the consumer make comparisons of fuel economy before making their choice, but none made any kind of quantitative

[6] Heywood, John. "Light-Duty Vehicle Technology: Fuel Consumption and GHG Emissions." Sloan Automotive Laboratory, Massachusetts Institute of Technology. PowerPoint presentation. 24 Aug 2007. Available online at <http://www.its.ucdavis.edu/events/outreachevents/asilomar2007/presentations/Day%202%20Session%201/John%20Heywood.pdf>.

[7] Cischke, Sue. "Sustainable Mobility: An Automaker Perspective on Transportation Climate Policy." Ford Motor Company. PowerPoint presentation. 23 Aug 2007. Available online at <http://www.its.ucdavis.edu/events/outreachevents/asilomar2007/presentations/Day%202%20Session%203/Sue%20C.pdf>.

[8] German, John. "Light Duty Vehicle Technology: Opportunities & Challenges." American Honda Motor Co., Inc. PowerPoint presentation. 23 Aug 2007. Available online at <http://www.its.ucdavis.edu/events/outreachevents/asilomar2007/presentations/Day%202%20Session%202/John%20German.pdf>.

[9] Myers Jaffe, Amy, and Kenneth B. Medlock III. "Energy Security, Climate and Your Car: U.S. Energy Policy and Beyond." James A. Baker III Institute for Public Policy, Rice University. PowerPoint presentation. 22 Aug 2007. Available online at <http://www.its.ucdavis.edu/events/outreachevents/asilomar2007/presentations/Day%201%20Session%202/JaffeTransportation%20and%20Climatepolicyfinalrevised2.pdf>.

[10] Kurani, Ken, and Thomas Turrentine. "Automobile Buyer Decisions About Fuel Economy and Fuel Efficiency." Institute of Transportation Studies, University of California, Davis. 2004. Available online at <http://repositories.cdlib.org/cgi/viewcontent.cgi?article=1105&context=itsdavis>.

assessment of the value of fuel savings. The study observes, "policies like fuel economy standards and rebates for purchasing more efficient vehicles will be more effective than gasoline or carbon taxes because they remove or reduce uncertainty about cost."

Reducing Greenhouse Gas Content in Fuel

Reducing the lifecycle greenhouse gas content of fuels can be accomplished by displacing liquid petroleum fuels with fuels made from other sources (see chart below for examples) including natural gas; fuels made from biomass including crops such as corn, sugar and seeds as well as cellulosic grasses, wood and plant waste; hydrogen; and electricity, which can be made from a vast range of materials. Policies which encourage the development of non-petroleum fuels need to insure (1) that the fuel's production is sustainable (see http://www.nrdc.org/air/transportation/biofuels/contents.asp) and (2) that the lifecycle greenhouse gases from the production and consumption of the fuel is increasingly lower than today's gasoline and diesel.

Electricity is the wild card

Using electricity to power a plug-in hybrid, assuming the average generating mix in the U.S., has been shown to result in considerably lower emissions of greenhouse gases than the burning of gasoline.[12] As the electric grid switches to lower greenhouse gas generation, electric vehicles get cleaner![13]

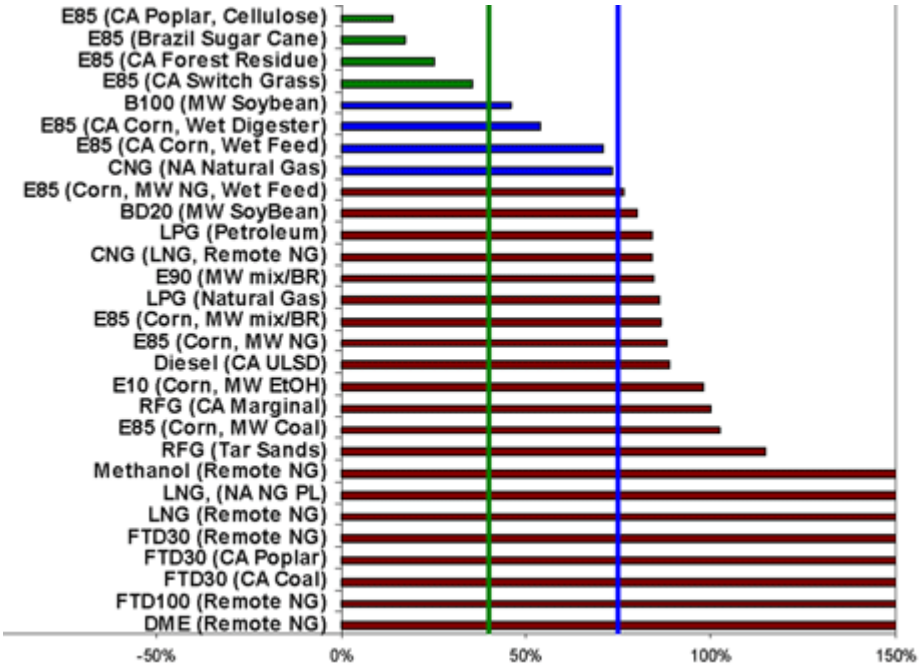
Fuel usage is divided among passenger vehicles, heavy-duty vehicles, ships and aircraft. Passenger vehicles are the most likely to be able to run on electricity due to shorter travel distances and less power requirements. A possible outcome is a focus on electricity for passenger vehicles while reserving oil for use by long-haul trucks and airplanes, which require the greater power density and range of hydrocarbon fuels.

The barrier for electricity has always been the availability of lightweight batteries with sufficient storage capacity and durability. One automotive researcher commented: "There are liars, damn liars and battery suppliers." Batteries are steadily improving, but there is no consensus on when batteries will have sufficient performance or low enough cost for wide adoption and commercialization in vehicles.

[11] Greene, David L., and John German. "Automotive Fuel Economy: The Case for Market Failure." Oak Ridge National Laboratory. PowerPoint presentation. 23 Aug 2007. Available online at <http://www.its.ucdavis.edu/events/outreachevents/asilomar2007/presentations/Day%202%20Session%202/The%20Case%20for%20Market%20Failure%20-%20Asilomar%20Aug07.pdf>.
[12] NRDC. "Climate Facts: The Next Generation of Hybrid Cars." July 2007. Available online at <http://www.nrdc.org/energy/plugin.pdf>.
[13] Electric Power Research Institute, NRDC. The Power to Reduce CO2 Emissions – The Full Portfolio. EPRI: 2007. Available online at <http://www.epri-reports.org/>.

Policy

California, the European Union and the U.S. EPA are all working on standards for measuring the lifecycle greenhouse gas produced from various fuels. An analysis done for the California Energy Commission demonstrates it is practical to accurately model the lifecycle emissions based on the specific raw energy source (referred to as the "feedstock") and processing technique.



Lifecycle greenhouse gas emissions of various fuels as compared to gasoline (gasoline = 100%) ordered from best to worst. Source: California Energy Commission document CEC-600-2007-004-D

Once lifecycle greenhouse gas standards are available, the market switch can occur through two means:

1. Low Carbon Fuel Standard (LCFS) - By establishing a gradually diminishing lifecycle greenhouse gas content standard for fuels, fuel suppliers will be required to invest in and distribute lower-carbon fuels. This technology-forcing policy does not pick winners or losers, as it is technology neutral. The California LCFS policy (see http://www.energy.ca.gov/low_carbon_fuel_standard/) is expected to require a 10 percent reduction in greenhouse gas intensity by 2020. Adoption of the policy is expected before 2009.
2. Consumer preference and pricing - Consumers will switch to alternative fuels if they are price-competitive, more convenient and/or appeal to consumers based on their improved environmental and national security values. For example, both natural gas and electricity offer the convenience of home refueling. A mile traveled using electricity is about one third the cost of a mile traveled using gasoline. Tax shifting can also be used to accelerate adoption. For example, a bill under consideration in California (AB 1190) would reduce taxes for fuels that are at least 25 percent lower in greenhouse gas emissions than gasoline.

Summary

Reducing greenhouse gases from transportation will require a combination of:

- Reduced vehicle miles traveled
- Improved vehicle fuel economy
- Reduced greenhouse gas content in fuel

None of the changes needed are likely to happen from pricing or the free market alone. They will depend on key policy changes, including:

- Federal funding preferences for projects intended to reduce VMT over highway expansion
- City, regional and state investments in transit and land-use planning for reduced VMT
- Federal standards for vehicle efficiency and greenhouse gas reductions
- Financial incentives for consumers for purchasing more fuel efficient vehicles
- Low-carbon fuel standards at state and national levels based on lifecycle greenhouse gas measurements

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